Chronic effect of resistant physical exercise on linear and nonlinear dynamics of heart rate variability in patients with type 2 diabetes mellitus

Efeito crônico do exercício físico resistido sobre a dinâmica linear e não-linear da variabilidade da frequência cardíaca de pacientes com diabetes mellitus tipo 2

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ABSTRACT

Introduction: Diabetes Mellitus (DM) can promote changes in the autonomic nervous system. Training with resistance exercise can contribute to the decrease of the glycemic level and improve the neural control of the heart. Objective: to verify the effects of resistance exercise training (RT) on linear and non-linear dynamics of autonomic heart rate (HR) modulation in patients with DM2. Methods: Eight patients with DM2 were studied. The R-R intervals of the HR were recorded in the supine resting condition and HRV was analyzed by linear and non-linear method. RT was performed for 12 weeks, with 60% 1RM, 5 exercises for large muscle groups. Results: data variations between post-RT and initial ones did not show statistical difference (p>0.05) in HRV calculated both by linear and non-linear methods. Conclusion: 12 weeks of moderate RT does not promote positive effects on HRV in patients with T2DM. Keywords: Resistance Training; Diabetes Mellitus; Heart Rate Variability.

RESUMO

Introdução: O Diabetes Mellitus (DM) pode promover alterações no sistema nervoso autonômico. O treinamento com exercício resistido pode contribuir com a diminuição do nível glicêmico e melhorar o controle neural do coração. Objetivo: verificar os efeitos do treinamento com exercício resistido (TR) sobre dinâmica linear e não linear da modulação autonômica da frequência cardíaca (FC) em pacientes com DM2. Métodos: foram estudados oito pacientes com DM2. Foram registrados os intervalos R-R da FC na condição de repouso supino e a VFC foi analisada por método linear e não linear. O TR foi realizado por 12 semanas, com 60% 1RM, 5 exercícios para grandes grupos musculares. Resultados: as variações dos dados entre pós TR e os iniciais não apresentaram diferença estatística (p>0.05) na VFC calculadas tanto pelo método linear quanto pelo não linear. Conclusão: 12 semanas de TR moderado não promove efeitos positivos sobre a VFC em pacientes com DM2. Palavras Chaves: Treinamento Resistido; Diabetes Mellitus; Função Autonômica Cardíaca.
INTRODUÇÃO

Type 2 Diabetes Mellitus (DM-2), responsible for 90 to 95% of cases, is characterized by chronic hyperglycemia caused by a deficiency in insulin production, due to the destruction of pancreatic β cells, and insulin resistance (MARASCHIN, 2010), causes damage to the peripheral nerve fibers of the autonomic nervous system (ANS) leading, as an evolution, to Cardiac Autonomic Neuropathy (CAN) in 40% of patients (SCHMID, 2007).

The vagus nerve is the first to be compromised (DIMITROPOULOS; TAHRANI; STEVENS, 2014) and subsequently the sympathetic innervation is from the apex to the base of the myocardium (TASKIRAN et al., 2004; POP-BUSUI et al., 2004), leading to to abnormal responses of heart rate (HR) and its variability, both at rest (POP-BUSUI, 2012) and during exercise or stress (VINIK and ZIEGLER, 2007; POP-BUSUI, 2012).

With the aim of improving the clinical picture and acting preventively in relation to comorbidities and mortality from DM-2, science has been investigating proposals for non-drug intervention, among which physical exercise (PE) has been gaining prominence. Regarding the effects of aerobic training in diabetics, the literature is vast and, although there is no general consensus, positive changes in cardiac autonomic modulation have been identified (HOWORKA et al., 1997; FIGUEROA et al., 2007; ZOPPINI et al. 2007; PAGKALOS et al., 2008; BHAGYALAKSHMI et al., 2010; SIMMONDS et al., 2012). As for combined resistance training associated with aerobic training, Sacre et al. (2014) identified improvement and Kang, Ko and Back (2016) found no changes in patients with DM-2.

With regard to the chronic effects of resistance physical training (RT), some studies have verified a reduction in glycated hemoglobin (ERIKSSON et al., 1997; DUNSTAN et al., 2002), body fat (IBANEZ et al. 2005; CAUZA et al. 2005), improved glycemic control (ARORA et al., 2009) and lipid profile (SIGAL et al., 2007), increased lean mass and muscle strength (DUNSTAN et al., 2002) in addition to attenuation of systolic blood pressure (SBP) in people with DM-2. However, scientific evidence regarding cardiac autonomic adaptations to RT is incipient. Loimaala et al. (2003) applied RT for 12 months in DM-2 and found an improvement in the baroreflex and resting HR, but there were no significant changes in Heart Rate Variability (HRV).

The HRV is an important tool used to evaluate the participation of the ANS on the heart (TASK FORCE, 1996). Linear methods using temporal and spectral analyzes are more used (VANDERLEI et al., 2009). However, considering that cardiovascular regulation presents non-linear dynamics and, therefore, some behaviors are not identified through linear methods (PORTA et al., 2007b), more recently, non-linear HRV analysis methods have been gaining increasing interest (GODOY, TAKAKURA, CORREA, 2005), among which we have the symbolic analysis (AS) that allows distinguishing, from a series of R-R intervals (iR-R), sequences of heartbeats, called patterns, and relating them to sympathetic and parasympathetic modulation independently.
(PORTA et al., 2001; GUZZETTI et al., 2005), providing additional and complementary prognostic information to traditional linear analyzes (VOSS et al., 2009).

Therefore, the present research aims to test the hypothesis that RT can contribute to the improvement of sympathetic and parasympathetic control of the heart in patients with DM-2.

METHODS

Study design

The sample was selected between June 2015 and January 2017 by inviting 129 individuals with DM2. The study was approved by the Ethics Committee in Research Involving Human Beings of the Faculty of Philosophy and Sciences of UNESP, Campus Marília, in accordance with Resolution 466/2012 and its Complements of the National Health Council (advice number: 083602/2016).

The sample size was obtained from the variations in the RMSSD values between the pre and post intervention moments of the Pagkalos study, (PAGKALOS et al., 2008) a type 1 error of 5% and a power of 80%, a sample of 6 elements was initially estimated samples. Considering a sample loss of 30%, 9 volunteers were selected. Subsequently, the study power of 56% was calculated, for a difference between the mean values of RMSSD of 2.8 (ms) and standard deviation of 3.2 (ms) and 8 sample elements studied.

Patients with non-insulin-dependent DM, aged between 45 and 75 years old, both sexes, not practicing RT in the last six months, able to practice physical exercise (PE) were included. And yet, with associated comorbidities such as dyslipidemia, obesity and systemic arterial hypertension (SAH). Also, non-inclusion criteria such as smokers, alcoholics, cardiovascular diseases (deep vein thrombosis, angina, arrhythmias, heart failure and myocardial infarction), as well as diagnoses of neoplasms, lung, kidney and neurological diseases unrelated to DM2.

The experiments were carried out in the same afternoon (between 2 pm and 6 pm), to standardize the influences of circadian variations on the organism in a climate-controlled room (temperature: 22-24 °C and relative humidity: 40-60%). The volunteers used appropriate clothing to carry out the experiments; did not ingest alcoholic beverages and/or stimulants (tea, coffee, soft drinks) 48 h before; not performing physical activities outside the daily routine; had a regular night's sleep and ate light food at least 2 hours before the experiments. All volunteers underwent data collection familiarization procedures at least 24 hours before the final collection.

HR and RR intervals were recorded (Polar® model RS800-CX) for 20 minutes in the supine position with spontaneous breathing. Time series with more than 95% of sinus beats were analyzed and 256 more stable points were selected for analysis (TASK FORCE, 1996) and linear indices were calculated in the time and frequency domains (Kubios HRV, version 3.0, University of Kuopio, Finland), and the nonlinear, derived from symbolic analysis (PORTA et al., 2007a)
Before and after the RT protocol, the evaluation procedures were performed on two days, with an interval of 48 to 72 hours between them. Day 1: Anamnesis, application of the Baecke Habitual Physical Activity questionnaire, clinical and physical assessment, vital signs, anthropometric measurements and body composition. Day 2: iR-R registration.

For the intervention, a RT program was designed according to the recommendations of the American Heart Association (POLLOCK et al, 2000) and the American College of Sports Medicine. The training consisted of two weekly sessions on alternate days using the following exercises: 1) legpress 45º; 2) extension table, knee extension in the sitting posture; 3) flexor table, knee flexion in the prone position; 4) peck deck, reverse crucifix; 5) horizontal bench press in sitting posture.

The training protocol consists of two sets of 15 repetitions for lower limb exercises (LL) and three sets of 15 repetitions for upper limbs with 60% of 1RM, 90-second interval (s) between sets, during 12 weeks, totaling 24 training sessions. The loads were adjusted weekly where the volunteers who, within their general conditions, should perform in the last series of the exercise a number greater than 15 repetitions and the additional repetitions served as a basis for increasing the load for the next session. Each repetition exceeded for the upper limbs and one kg for each additional repetition of the lower limbs. Volunteers who participated at least 85%, in the other words, 20 sessions, were reevaluated.

**Statistical analysis**

The variables were analyzed by their quantitative values and are described by the mean and standard deviations. Qualitative variables are described by the relative (%) and absolute (f) frequency distribution. The normality distribution was verified by the Shapiro-Wilk test. For the conditions for which the effect is intended to be analyzed, the delta variation (Δ) was calculated, the difference between post and pre-training moments. To compare two means within the group, the t test was used student for paired sample or the Wilcoxon test when the data violated the assumption of normality distribution. For correlation tests, Pearson’s tests were used for normal data and Sperman’s tests for those that did not present normal distribution. For all analyses, SPSS software version 19.0 for Windows was used, with a significance level of 5%.

**RESULTS**

The sample was selected between June 2015 and January 2017 by inviting 129 individuals with DM2, however only eight completed the study, as described in the flowchart below.
The sample consisted of DM2, being four women and four men, with a mean age of 62.37±9.65 years, little active, according to the Physical Exercise and Leisure score, 2.31±0.49 points, of the questionnaire from Baecke. Eating habits, sleep and current medication were maintained throughout the study period.

There were no significant changes in blood biochemistry (Table 1), iR-R, linear (temporal and spectral) and non-linear HRV indices after RT (Table 2).

**Table 1.** Absolute data before and after resistance training variation of the blood biochemical variables of the volunteers studied (n=8).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Results</th>
<th>Δ</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood glucose (mg/ dL)</td>
<td>118.13±24.03</td>
<td>10.37±16.30</td>
<td>0.11</td>
</tr>
<tr>
<td>TC (mg/dL)</td>
<td>191.00±41.56</td>
<td>-5.00±30.27</td>
<td>0.65</td>
</tr>
<tr>
<td>LDL (mg/dL)</td>
<td>106.47±49.13</td>
<td>-10.20±51.93</td>
<td>0.59</td>
</tr>
<tr>
<td>HDL (mg/dL)</td>
<td>48.25±16.45</td>
<td>-0.75±14.45</td>
<td>0.88</td>
</tr>
<tr>
<td>TG (mg/ dL)</td>
<td>201.50±85.80</td>
<td>9.62±68.39</td>
<td>0.70</td>
</tr>
</tbody>
</table>

**Note:** mg/ dL: milligrams per deciliter; TC: total cholesterol; LDL: low density lipoprotein; HDL: high density lipoprotein; TG: triglycerides.
Table 2. Absolute data before and variation (Δ) after resistance training of linear indices (temporal and spectral) and symbolic indices (n=8).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre</th>
<th>Δ</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temporal Indexes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- R-R (ms)</td>
<td>828.2±110.0</td>
<td>58.1±98.1</td>
<td>0.1</td>
</tr>
<tr>
<td>- HR (bpm)</td>
<td>73.5±8.8</td>
<td>-4.8±7.2</td>
<td>0.1</td>
</tr>
<tr>
<td>- SDNN (ms)</td>
<td>21.9±7.5</td>
<td>2.4±7.3</td>
<td>0.4</td>
</tr>
<tr>
<td>- RMSSD (ms)</td>
<td>17.1±6.1</td>
<td>3.0±7.5</td>
<td>0.3</td>
</tr>
<tr>
<td>- SD1 (ms)</td>
<td>12.1±4.3</td>
<td>2.1±5.3</td>
<td>0.3</td>
</tr>
<tr>
<td>- SD2 (ms)</td>
<td>28.1±10.6</td>
<td>-2.8±9.2</td>
<td>0.4</td>
</tr>
<tr>
<td>- SD1/SD2</td>
<td>0.5±0.2</td>
<td>-0.0±0.1</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>Spectral Indices</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- LF (ms²)</td>
<td>104.2±72.6</td>
<td>48.0±0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>- HF (ms²)</td>
<td>150.0±141.6</td>
<td>15.0±121.9</td>
<td>0.6</td>
</tr>
<tr>
<td>- LF (un)</td>
<td>47.2±22.4</td>
<td>6.1±12.9</td>
<td>0.2</td>
</tr>
<tr>
<td>- HF (un)</td>
<td>52.8±22.4</td>
<td>-6.1±12.9</td>
<td>0.2</td>
</tr>
<tr>
<td>- LF/HF</td>
<td>1.3±1.0</td>
<td>0.0±0.5</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Symbolic Analysis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 0V%</td>
<td>19.5±11.3</td>
<td>0.0±9.2</td>
<td>1.0</td>
</tr>
<tr>
<td>- 1V%</td>
<td>47.3±6.3</td>
<td>-0.3±4.2</td>
<td>0.7</td>
</tr>
<tr>
<td>- 2LV%</td>
<td>12.1±10.6</td>
<td>-2.4±8.3</td>
<td>0.4</td>
</tr>
<tr>
<td>- 2UV%</td>
<td>21.1±8.9</td>
<td>2.7±8.8</td>
<td>0.4</td>
</tr>
<tr>
<td>- IC</td>
<td>1.0±0.1</td>
<td>0.0±0.2</td>
<td>0.7</td>
</tr>
<tr>
<td>- ICN</td>
<td>0.7±0.1</td>
<td>0.0±0.1</td>
<td>0.6</td>
</tr>
</tbody>
</table>

**Note:** R-R: R-R interval; HR: heart rate; SDNN: standard deviation of all normal iR-Rs recorded in a time interval, expressed in ms; RMSSD: square root of the mean square of the differences between adjacent normal iR-Rs, in a time interval, expressed in milliseconds; SD1: standard deviation of the distances of the points to the diagonal y=x of the Poincare plot; SD2: standard deviation of the distances of the points to the line y=-x+RRm, where RRm is the mean of the iR-R; LF: low frequency; HF: high frequency; un: normalized units; ms²: milliseconds squared; %: percentage; 0V: no variation in the triad; 1V: one variation; 2LV: two equal variations; 2UV: two different variations; CI: complexity index; ICN: Normalized Complexity Index.

**DISCUSSION**

It was found in the present study that the proposed RT was not able to change fasting glucose, lipid profile, global and abdominal obesity, as well as sympathetic and parasympathetic control of the heart of the individuals with DM2 studied.

The proposed protocol followed literature recommendations for individuals with DM with a focus on glycemic control and overall health improvement (POLLOCK et al., 2000) We
use specific equipment that provides comfort and safety for the execution of movements; moderate intensity and volume; one to three runs (COLBERG et al., 2016) We used five exercises, two to three sets, with a 90-second rest between sets, with a minimum frequency of two non-consecutive days a week.

Regarding the increase in load, Colberg et al (2016) advocated that the intensity should be increased to a vigorous level with progressive increases in load and a lower number of repetitions per series. In this study, the increase in loads occurred weekly, however, moderate levels of overload were maintained in order to prevent musculoskeletal and joint injuries and thus not provide training withdrawal. The prescriptions were individualized and adapted according to the health conditions evaluated and the need of each participant regarding the performance of the exercises (DESCHENES and KRAEMER., 2002).

The methodology used to define training loads, weekly progression as well as cardiovascular monitoring by HR and BP proved to be applicable and did not promote musculoskeletal and/or cardiovascular overloads.

**Blood Biochemistry**

The findings regarding fasting blood glucose were similar to other studies, (ERIKSSON et al., 1997; IBANEZ et al. 2005) but they differed from those (CAUZA et al., 2005; ARORA, SHWETA e SANDHU, 2009) that found a decrease in this variable, as well as in HbA1c ((DUNSTAN et al., 2002; CAUZA et al., 2005; ARORA, SHWETA e SANDHU, 2009) after RT.

Larose et al (2010) who used different training intensity, point out that the RT performed for six months, two to three times a week, with seven exercises, using the main muscle groups with high intensity, that is, weights that cannot be overcome. more than eight or ten times by the patient controls the glycemic indexes. The protocol applied in our study shows differences in terms of duration, frequency, intensity and number of exercises, these components being lower than those of other authors Larose et al. (2010), Dunstan et al. (2002), Cauza et al. (2005) e Arora, Shweta e Sandhu (2009) and this factor may have been fundamental for the non-modification of fasting glycemia with the TR.

The improvement in the glycemic profile has been attributed to a decrease in central adiposity, an increase in physical fitness (SENECHAL et al, 2013), a decrease in global obesity and an increase in lean mass (DUNSTAN et al., 2002). However, these variables did not change in the present study. The decrease in visceral fat may, in part, be responsible for the reduction of HbA1c (SENECHAL et al, 2013) and improvement of glycemic control in DM2 (BOUDOU et al., 2003), and this visceral fat decrease is related to the attenuation of free fatty acids, improving glucose disposal and, consequently, would benefit the glycemic control (GIANNOPOULOU et al., 2005).
Other factors associated with improved glycemic profile with RT may be increased capillary density and GLUT4 content (ARORA, SHWETA e SANDHU, 2009) as well as better insulin sensitivity (HOLTEN et al., 2004). GLUT4 is an insulin-dependent transporter responsible for glucose uptake and its increase with TR can reach 40% in DM2 (HOLTEN et al., 2004).

The literature states that glycemic control is best studied with HbA1c analysis in people with DM2 (CHURCH et al. 2010; SENECHAL et al, 2013) and that a 0.34% reduction in HbA1c can reduce the risk of cardiovascular disease in these patients by 5 to 7% (CHURCH et al. 2010). However, this variable was not measured in the present study.

Regarding circulating lipids, our findings corroborate studies that did not find changes in the lipid profile (ERIKSSON et al., 1997; IBANEZ et al, 2005); even when associated with diet, loss of body mass and training for a longer period, 6 months (DUNSTAN et al, 2002). However, it differs from others (CAUZA et al., 2005; CAMBRI et al., 2007) who found an improvement in this profile. Cauza et al (2005) associate that this improvement occurred at the expense of beneficial adjustments that occurred in body composition with a decrease in the % of body fat and an increase in lean mass. However, Castaneda et al (2002) found an increase in lean mass, but not in the lipid profile with high-intensity RT, and Dunstan et al (2002) in long-term RT found an improvement in body mass, decrease in percentage of fat mass and the lipid profile did not change. Thus, the interference of RT on the lipid profile still points to uncertainties in the literature both regarding its occurrence and the possible mechanisms in patients with DM2.

Heart rate variability: chronic adaptation

Martins-Pingue (2011) points out that among the beneficial effects promoted with regular PE is the decrease in sympathetic activity on the cardiovascular system in the condition of rest or exercise. On the contrary, sympathetic hyperactivity is frequent in cardiovascular pathological conditions. Changes in the cardiovascular regions of the brainstem and other regions that are influenced by physical activity levels are likely to play a role in long-term cardiovascular health.

In a review on the effects of RT on the neural control of the heart, it was found that of the eight studies evaluated, only one presented chronic adaptation of HRV, indicating that RT does not promote beneficial effects on HRV at any age (KINGSLEY et al 2016). In relation to healthy elderly people, some studies did not verify adaptation of HRV indices to TR (GERAGE et al., 2013; WANDERLEY et al., 2013) while a study (MELO et al., 2008) found an increase in the LF index, which presents sympathetic predominance, and a decrease in the HF representative of the vagus.

Zoppini et al (2007) applied a 6 months intervention with aerobic training, 2 sessions per week, in 12 elderly people with DM2 and assessed HRV and baroreflex. In addition to the baroreflex improvement, HRV also showed significant changes after training with LF attenuation and HF increase and, consequently, attenuation of the ratio between the two indices.
In another study, Loimaala et al (2003) applied RT in 50 patients with DM2 for 12 months, a protocol with 8 exercises of large muscle groups with 70 to 80% of the RM, three sets of 10 to 12 repetitions. Resting HRV indices (SDNN, PNN50, HF, LF and LF/HF ratio) did not change with training. However, baroreflex index and HR improved with training. The authors point out that there was a trend towards an increase in HRV, indicating a potential for RT to improve the ANS if it is applied for a longer period of intervention in patients with DM2.

In the study by Melo et al (2008), RT promoted effects on cardiovascular variables, including HR and HRV in the elderly, however in a negative way, with an increase in the LF/HF ratio, in addition to worsening vagal modulation and increased sympathetic activity. The authors attributed this phenomenon to the supposed increase in catecholamines, related to greater sympathetic participation after RT. However, baseline HR did not change and this fact may be associated with a reduction in the beta-adrenergic response, which is also an assumption of the possible mechanism involved in autonomic modulation.

Studies involving samples with established pathological conditions show positive results from RT on autonomic HR modulation. Patients with chronic heart failure (SEILIG et al., 2004) after 12 weeks of RT, three weekly sessions with six exercises, significantly attenuated the LF index (un) and increased the HF index (un) in relation to the control group. Positive results also occurred in patients with coronary artery disease (CARUSO et al. 2014) with increases in the RMSSD and SD1 indexes observed after 8 weeks of RT compared to the control group.

Regarding aerobic training, studies with six months of intervention (ZOPPINI et al., 2007; PAGKALOS et al., 2008) and twelve weeks (SIMMONDS et al., 2012) promote changes in HRV indices. In relation to the RT, twelve months (LOIMAALA et al., 2003) were not enough to promote changes in HRV. In a recently published review on the chronic effects of exercise on the HRV of DM2, Giacon et al (2017) pointed out that it can positively influence adaptations in the ANS and HRV is an important tool for this analysis, however, it seems that these modifications seem to depend on the characteristics of the patient. exercise such as type, frequency and intensity.

In the present study, we also used the non-linear HRV analysis method in order to explore more broadly the information about the ANS action on the heart, since some authors (TARVAINEN et al., 2014; VANDERLEI et al., 2009;) refer that this method provides information about the complexity of regulatory systems and, when compared to temporal and spectral analysis methods, they have the possibility of presenting the dynamic and complex nature of physiological systems (VANDERLEI et al., 2009) a fact that the others do not have. In addition to allowing the non-reciprocal analysis of sympathetic and parasympathetic indices that involve autonomic modulation (PORTA et al., 2007b).

Regarding the use of non-linear analysis as a parameter and evaluation of the effect of RT, no studies with DM2 were detected. Gerhart et al (2017) also found no changes in the
Shannon entropy indices of elderly women after 12 weeks of RT with three sets of eight to 12 repetitions, nine exercises, intensity from 50 to 60% of 1RM and progression up to 75-85%.

Research on AS is recent and few publications involve this analysis methodology. Studies related to gender (PERSEGUINI et al., 2011), to age (CATAI et al., 2014) and postural change (PERSEGUINI et al., 2011; GUZZETTI et al., 2005) are initially documented. In patients with DM2 Moura-Tonello et al, (2014) the 0V component showed higher percentages in the supine resting condition, demonstrating sympathetic predominance in the DM2 studied. In our results the predominance was of component 1V, pre and post intervention, which is related to both sympathetic and parasympathetic systems. Regarding the specific sympathetic and parasympathetic components, our data showed a greater participation of 2UV (21.06%) in relation to 0V (19.48%) even after RT. These data do not corroborate with Moura-Tonello 43 who found a sympathetic predominance (0V).

In the present study, we did not find changes in AS components as a chronic effect of RT. The absence in the literature of research involving the methodology adopted here for confrontation leaves us limited to a more secure position on the relevance of AS for the purpose presented here. However, the fact that AS presents specific components for the sympathetic and vagal systems in a non-complementary way, such as spectral analysis, provides relevant information for a better understanding of the ANS action on the heart and the possible effects of therapies on it.

Thus, more information is needed about the effects of RT from this perspective of HRV assessment in order to verify its real importance as a parameter to assess the effects of non-pharmacological therapies on DM2, such as PE.

In the present study, the indices that reflect the action of the ANS on the HR did not show any changes, possibly because they are associated with some factors such as training time, intensity considered light-moderate, proposed training volume with five exercises and also, the protocol application time, which was twelve weeks, since the improvement of cardiac autonomic function achieved both by RT and by another training modality in individuals with dysautonomia is still not clear and the duration of the training stimulus and the exercise prescription need be investigated to really understand the effects of RT on the ANS (KINGSLEY e FIGUEROA, 2016).

Clinical Applications

The RT proposal applied in the present research proved not to be able to modify the HRV of people with DM2 with the profile studied. However, it proved to be applicable for the group given the absence of injuries, discomfort and/or limitations that can occur with the practice of aerobic exercise, for example. Furthermore, the progression system adopted was well tolerated and the exercise load gradually increased for both upper and lower limbs. Thus, the practice of RT should be encouraged as a routine practice for this population.
Final Considerations and Study Limitations

The chronic effects of RT are still being explored when it comes to patients with DM2. The evidence in the literature is still conflicting, mainly regarding possible beneficial changes in HRV. Thus, a greater number of studies need to be developed with optimized and similar protocols in order to more assertively investigate whether RT can bring benefits in the autonomic response of HR.

It was not possible to observe an improvement in glycemic control more safely because we did not analyze HbA1c to better verify this parameter. Furthermore, the small number of participants in the sample and the absence of the control group may have limited a better understanding of the chronic effects of RT in the population studied.

One aspect to be considered is the number of individuals studied. Despite the sample calculation indicating nine elements, the proposal was to have a greater N, however this was not possible due to the rigor of the inclusion criteria, which is necessary for the credibility of the study, and the lack of interest of the volunteers in relation to the training. Of the 129 individuals screened, 23% were included and only 6% completed the protocol (study). In a Canadian study, (SIGAL et al. 2007), of the 2282 volunteers with T2DM recruited, 17% were included and 11% completed the training.

Regarding the adherence of those included, the volunteers completed 97% of the scheduled sessions in this study, superior to Sigal et al, (2007) who achieved adherence in 86% of the sessions. These data suggest that the difficulty lies more in recruiting volunteers than in participating in therapy.

Another limitation refers to diseases associated with DM2. Although these are part of the clinical reality of these patients, the subgroups by disease are less representative. Likewise, the number of diseases present and the respective medications vary from one individual to the next.

CONCLUSION

The data of the present study suggest that 12 weeks of moderate RT, 60% of 1RM, with a weekly frequency of twice can be practiced with tolerance by diabetic elderly, however, this protocol did not promote changes in fasting glucose, lipi1d profile, body composition and HRV indices in the population studied.

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